DTIC FILE COPY

(2)

AD-A198 578

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TR- 88-0783
6a. NAME OF PERFORMING ORGANIZATION Signal & Image Processing Univ of So. California; 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION AFOSR/NE
6c. ADDRESS (City, State and ZIP Code) Mail Code 2072 Los Angeles, CA 90089-0272	7b. ADDRESS (City, State and ZIP Code) Bldg 410 Bolling AFB, DC 20332-6448
8a. NAME OF FUNDING/SPONSORING ORGANIZATION AFOSR; 8b. OFFICE SYMBOL (If applicable) NE	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-86-0316
8c. ADDRESS (City, State and ZIP Code) Bldg 410 Bolling AFB, DC 20332-6448	10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.
61102 F	2917	A3	

11. TITLE (Include Security Classification) RSCH INSTRUMENTATION FOR COMPUTER VISION, IMAGE UNDERSTANDING & OPTICAL COMPUTING

12. PERSONAL AUTHOR(S) DR. CHELLAPPA

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
FINAL	FROM 01Sep86 TO 28Feb88		

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The following equipment was purchased SUN 3/160 workstation, 2 SUN 3/110 workstation memory boards and floating point accelerators, a Microvax II dedicated host computer, TI Explorer II AI workstation. The equipment acquired has greatly improved research productivity in the projects listed by providing up-to-date hardware and software capable of performing advanced experimental projects which could not be done on previously available equipments.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL GILES	22b. TELEPHONE NUMBER (Include Area Code) (202) 767-4932; 22c. OFFICE SYMBOL NE

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

88 8 25 150

SECURITY CLASSIFICATION OF THIS PAGE

AFOSR-TR- 88-0783

Final Technical Report for

Grant AFOSR-86-0316

RESEARCH INSTRUMENTATION FOR COMPUTER VISION, IMAGE UNDERSTANDING AND OPTICAL COMPUTING

R. Chellappa, Principal Investigator

Signal and Image Processing Institute
University of Southern California
Mail Code 0272
Los Angeles, California 90089-0272
(213) 743-8559

Research Sponsored by the

Air Force Office of Scientific Research
Electronics and Materials Science Division
AFOSR/NE
Bolling AFB, Bldg. 410
Washington, D.C. 20332

Performance Period: 1 September 1986 - 28 February 1988

Contents

1 Summary

The funds received under Grant AFOSR-86-01-316, "Research Instrumentation for Computer Vision, Image Understanding and Optical Computing," went for the purchase of equipments in support of several current AFOSR funded research projects at USC. These projects include: Image Processing and Computer Vision, Optical Symbolic and Neural Computing and Nonlinear Optical Information Processing. The equipment purchased consists of the following components: SUN 3/160 workstation, 2 SUN 3/110 workstations, memory boards and floating point accelerators, a Microvax II dedicated host computer, TI Explorer II AI workstation. The equipment acquired has greatly improved research productivity in the projects listed by providing up-to-date hardware and software capable of performing advanced experimental projects which could not be done on previously available equipments.

2 Research Progress

This section summarizes research progress and accomplishments for the period 1 September 1986–28 February 1988 on AFOSR-86-0316 for Research Instrumentation for Computer Vision, Image Understanding and Optical Computing.Funds received on this grant went for the purchase of equipments in support of several current AFOSR funded research projects at USC. The projects are very closely related and are specifically:

- Image Processing and Computer Vision
- Optical Implementation of Neural Networks for Computer Vision
- Nonlinear Optical Information Processing
- Optical Symbolic Computing

Common to all these areas of research is the need for:

- Extensive numerical simulation and modeling of devices, processors and systems.
- Computationally intensive transforming and analysis of algorithms performed on large arrays of image and other multidimensional data.
- Solution of optimization problems involving multidimensional nonlinear equations.
- Interframe processing between several arrays of image data.
- Interactive display, manipulation and plotting of images and graphic representations of the results.

The equipment purchased consists of an interactive display/computing system with the following components.

- SUN 3/160 workstation: 16MB memory, 280 disk, FPA; LISP, image processing, optimization, scientific subroutine.

- SUN 3/110 workstations connected to a SUN 3/280 server, 12 MB MEMORY, FPA; Rochester connectionist Simulator.

- DEC Microvax II workstation: with 9 MB memory, 280 MB disk, 8 terminal lines, ethernet interface and a cartridge tape mount.

- TI Explorer II AI workstation: with 16 MB memory, 540 MB disk and network interfaces.

The following is a complete list of items purchased under this grant and their price.

	ITEM	QUANTITY	COST
1.	SUN 3/110G Workstation	2	$22,446.81
2.	SUN 3/160G Workstation with 280 MB software and license	1	40,219.06
3.	Toshiba 510 MB disk with panel and Controller	1	3,509.80
4.	DEC - Microvax - II Work station, ethernet interface	1	37,777.39
5.	DEC - Unix 32 M	1	2,609.33
6.	8 MB Memory Board for SUN 3 computers	3	8,393.85
7.	Floating point accelerators for SUN 3 computers	2	6,789.05
8.	Texas Instruments Explorer-II Workstation with 16 MB memory 540 MB disk, ethernet interface	1	28,992.27
	Total	=	$150,737.56
		AFOSR Funds	$132,000.00
		USC Funds	$18,737.56

The system acquired has greatly improved research productivity in the projects listed by providing up-to-date equipment capable of performing the experimental tasks described. The enhanced research environment afforded by the system has enabled many new experimental projects to be performed which could not be done on previous equipment. The results are discussed separately in the sections that follow.

2.1 Research in Computer Vision

R. Chellappa, Principal Investigator
Support: Research in Electronics (JSEP),
AFOSR contract F - 49620-85-C-0071
Dr. Gerald Witt, AFOSR/NE, Technical Monitor

The goal of this research project is to develop robust intelligent algorithms for the interpretation of visible and SAR aerial images. During the last two years, robust stochastic model based algorithms have been developed for the extraction of edges, corners, lines, textures and topographical descriptors from visible images. Using the reflectance models for SAR images and auxiliary low resolution altimetry data, high resolution terrain maps have been extracted from SAR images. Implementations of these algorithms were done on the equipment purchased under this grant. In the next three years, these efforts will be extended to develop a knowledge based image analysis system for the intelligent interpretation of visible and SAR images. Emphasis will be on detecting man made objects.

2.2 Nonlinear Real-Time Optical Signal Processing

A.A. Sawchuk, Principal Investigator
Support: AFOSR Grant AFOSR-84-0181
Dr. Lee Giles, AFOSR/NE, Technical Monitor

During the period 1 September 1986 - 28 February 1988, the research under the above grant has been concerned with various aspects of optical digital computing. In this period we have concentrated on hardware and software implementations of digital optical cellular image processing. We have developed binary image algebra (BIA), comprised of five elementary images and three fundamental operations (complement, union and dilation) that serves as a mechanism to define parallel binary image processing algorithms. A hardware design called DOCIP (digital optical cellular image processors), derived from cellular automata and cellular logic architectures has been developed. DOCIP is ideally matched to the parallel software developed from BIA, and is well-suited to parallel implementation on a parallel digital optical computer. DOCIP systems having nearest neighbor connections and hypercube connections have been defined and comparisons of their capabilities are being made.

2.3 Optical Symbolic and Neural Computing

B. K. Jenkins, Principal Investigator
Support: AFOSR Grant 86-0196
Dr. Lee Giles, AFOSR/NE, Technical Monitor

We have developed a new learning algorithm, potential difference learning, for self organizing neural networks. It updates the weights in proportion to the correlation of the presynaptic signal with the temporal difference of the postsynaptic potential. It can learn on the basis of temporal differences of input patterns or on the basis of absolute patterns. We have simulated it on a Hopfield or Amari net and on a three layer net. The three layer net consists of two Amari nets connected by a hidden layer; the hidden layer serves to associate patterns that are stored in the two visible layers. We have also shown how it can be used for unlearning or erasing a particular stored pattern in an Amari net, merely by inputting patterns in a presrcibed sequence: direct access to the weights, and/or reversing the sign of the learning gain, is not necessary. We have also described an optical architecture for the implementation of potential difference learning.

We have developed a technique for subtracting incoherent optical signals using all-optical devices, called an incoherent optical neuron (ION) model. This permits a neural net to be implemented with all-optical devices, even if it has positive and negative synaptic weights, and excitatory and inhibitory inputs. It is generic in that it can be used in both fully or partially connected networks, multi-layer, single-layer, feedforward or recurrent networks, using analog (sigmoid) or binary neurons units. It assumes conventional inner-product type neuron units. We have simulated the model for imperfect device responses, on an on-center off-surround competitive neural net. We have found that it is fairly forgiving of device imperfections, nonuniformities, and noise.

We have also investigated complexity issues regarding optical computing. A model for digital optical computing systems was derived that is analogous to common VLSI complexity models. It was found that in optics the area-time tradeoff becomes a volume-time tradeoff and permits essentially any amount of information transfer in any time step of the computation. Further, because the information transfer (that is, the interconnection capability) does not give a limit on the computing power of optical systems, a realistic complexity model must characterize the factors that will limit the computing capability. Such a model would be very different from that in electronics, because in electronics all VLSI complexity models are derived from, and focus essentially exclusively on, interconnection limitations.

3 Written Publications

During the period 1 September 1986 through 28 February 1988, a number of papers based on this research have been published. A list of these follows:

[1] K. S. Huang, B. K. Jenkins and A. A. Sawchuk, " Binary Image Algebra and Optical Cellular Logic Design," submitted to *Computer Vision, Graphics, and Image Processing.*

[2] K. S. Huang, B. K. Jenkins and A. A. Sawchuk, "An Image Algebra Representation of Parallel Optical Binary Arithmetic," submitted to *Applied Optics.*

[3] K. S. Huang, B. K. Jenkins and A. A. Sawchuk, " Programming a Digital Optical Cellular Image Processor," Optical Society of America Annual Meeting, Rochester, NY, October 1987, *J. Optical Soc. Amer. A.*, Vol 4, pp. 87-88, 1987.

[4] K. S. Huang, B. K. Jenkins, and A. A. Sawchuk, "Binary Image Algebra Representations of Optical Cellular Logic and Symbolic Substitution," Optical Society of America Annual Meeting, Rochester, NY, October 1987; *J. Optical Soc. Amer. A.*, Vol. 4, pp. 87-88, 1987.

[5] K. S. Huang, B. K. Jenkins, A. A. Sawchuk, "A Cellular Hypercube Architecture for Image Processing," Proceedings Society of Photo-Optical Instrumentation Engineers Technical Symposium-Applications of Digital Image Processing, *SPIE Vol. 829*, San Diego, August 1987.

[6] K. S. Huang, B. K. Jenkins and A. A. Sawchuk, "Optical Cellular Logic Architectures Based on Binary Image Algebra," *Proc. IEEE Computer Society Workshop on Computer Architectures for Pattern Analysis and Machine Intelligence*, Seattle, WA., October 1987.

[7] B. K. Jenkins and A. A. Sawchuk, "Binary Optical Computing Architectures," *Optics News* Vol 12, No. 4, pp. 25-26, (April 1986).

[8] A. Armand, T. C. Strand and A. A. Sawchuk, "Nonlinear Optical Processing and Halftones: Accurate Predictions for Degradation and Compensation". *Applied Optics*, vol. 26, pp. 1007-1014, (15 March 1987).

[9] K. S. Huang, B. K. Jenkins and A.A. Sawchuk, "Binary Image Algebra and Digital Optical Cellular Processors," *Technical Digest*, Topical Meeting on Optical Computing, Optical Society of America, Incline Village, NV, March 16-18, 1987.

[10] R. T. Frankot and R. Chellappa, "Lognormal Random Field Models and Their Applications to Radar Image Synthesis," *IEEE Transactions Geoscience and Remote Sensing*, vol. GE-24, pp. 195-207, March 1987.

[11] C. C. Lin and R. Chellappa, "Classification of 2-D Partial Shapes Using Fourier Descriptors," *IEEE Trans. Patt. Anal. Mach. Intell*, vol. PAMI-9, PP. 686-690, September 1987,

[12] R. Hansen, Jr. and R. Chellappa, "Two Dimensional Robust Spectral Estimation," (To appear -*IEEE Trans. Acoust., Speech and Signal Proc.*), July 1988.

[13] Y. T. Zhou, R. Chellappa, B. K. Jenkins and A. Vaid, "Image Restoration Using a Neural Network," (Accepted for Special Issue on Neural Networks, *IEEE Trans. Acoust., Speech and Signal Processing*, July 1988).

[14] Y. T. Zhou, A. Rangarajan and R. Chellappa, "A Unified Approach for Filtering and Edge Detection in Noisy Images", *(Submitted for publication)*.

[15] T. Simchony, R. Chellappa, J. Hao, and Z. Lichtenstein, "A Stochastic Relaxation Algorithm for the Restoration Array Level Images Completed by Multiplicative and Poisson Noise," *(Submitted for Publication)*.

[16] T. Simchony and R. Chellappa, "Stochastic and Deterministic Algorithms for Texture Segmentation," *(Submitted for Publication)*.

[17] G. S. Young and R. Chellappa, "3-D Motion Estimation Using a Sequence of Noisy Stereo Images: Models, Motion Estimation and Uniqueness Results," *(Submitted for Publication)*.

[18] T. Simchony R. Chellappa, and S. Min, "Direct Analytical Methods for Solving Poisson Equations in Computer Vision Problems," *(Submitted for Publication)*.

[19] R. T. Frankot and R. Chellappa, "Estimation of Surface Topography from SAR Images Using Shape from Shading," *(Submitted for Publication)*.

[20] T. J. Broida and R. Chellappa, "Estimating Kinematics and Structure of a Rigid Object from a Sequence of Noisy Monocular Images," *(Submitted for Publication)*.

[21] R. Chellappa, "Model Based Approaches for Some Image Understanding Problems," *Proc-SPIE*, Los Angeles, January 1987. *(Invited Paper)*

[22] R. Chellappa, T. Simchony and H. Jinchi, "Relaxation Algorithms for MAP Restoration of Gray Level Images with Multiplicative Noise", *Conf. Inform. Sciences and Systems*, Baltimore, MD, March 1987.

[23] Y. T. Zhou, A. Rangarajan, and R. Chellappa, "A Unified Approach for Filtering and Edge Detection in Noisy Images", *Proc. 21st Annual Asilomar Conf. on Systems, Signals, and Computers*, Monterey, CA., November 1987.

[24] R. T. Frankot and R. Chellappa, "Application of a Shape from Shading Technique to Synthetic Aperture Radar Imagery," *Intl. Geoscience and Remote Sensing Symposium*, Ann Arbor, MI, May 1987.

[25] Y. T. Zhou and R. Chellappa, "Linear Texture Extraction Based on an AR Model Edge Detector," *Intl. Conf. Acoustics, Speech and Signal Proc.*, Dallas, Texas, April 1987.

[26] Y. T. Zhou, R. Chellappa, and G. Bekey, "Estimation of Filtering Properties of Living Tissues for Inverse Filtering of Surface EMG Signals," *Intl. Conf. Acoustics, Speech and Signal Proc.*, Dallas, Texas, April 1987.

[27] R. T. Frankot and R. Chellappa, "A Method for Enforcing Integrability in Shape from Shading Problems," *First Intl. Conf. on Computer Vision*, London, June 1987.

[28] Y. T. Zhou, R. Chellappa and B. K. Jenkins, "A Novel Approach to Image Restoration Based on a Neural Network," *First Annual Intl. Conf. on Neural Networks*, San Diego, CA, June 1987.

[29] R. Hansen Jr. and R. Chellappa, "2-D Spectrum Estimation for Imperfectly Observed Lattice Data," *Intl. Conf. Acoust., Speech and Signal Proc.* Dallas, Texas, April 1987.

[30] D. S. Kalivas, A. A. Sawchuk, and R. Chellappa, "Estimation and Segmentation of Image Sequences," *Proc. SPIE Conference*, San Diego, CA, August 1987.

[31] C. H. Wang and B. K. Jenkins, "Potential Difference Learning and Its Optimal Design," *Proc. SPIE*, vol. 882, January 1988.

[32] B. K. Jenkins and C. H. Wang, "Model for an Incoherent Optical Neuron that Subtracts," (Submitted for Publication).

4 Professional Personnel and Advanced Degrees

The following individuals contributed to the research efforts supported by this grant:

Dr. Rama Chellappa, Associate Professor of Electrical Engineering, Principal Investigator.

Dr. Alexander A. Sawchuk, Professor of Electrical Engineering, Director, Signal and Image Processing Institute, Senior Investigator

Dr. Brian K. Jenkins, Assistant Professor of Electrical Engineering, Senior Investigator

Dr. Allan Weber, Manager, Signal and Image Processing Institute, USC

Kung-Shiuh Huang, Research Assistant, Ph.D candidate, Department of Electrical Engineering

Dr. Ted J. Broida, formerly Research Assistant, Ph.D. candidate, Department of Electrical Engineering, now at Hughes Aircraft Company.

Dr. R. T. Frankot, formerly Research Assistant, Ph.D. candidate, Department of Electrical Engineering, now at Hughes Aircraft company.

Richard Hansen Jr., Research Assistant, Ph.D. candidate, Department of Electrical Engineering.

Tal Simchony, Research Assistant, Ph.D. candidate, Department of Electrical Engineering.

V. Venkateswar, Research Assistant, Ph.D. candidate, Department of Electrical Engineering.

Yi-Tong Zhou, Research Assistant, Ph.D. candidate, Department of Electrical Engineering.

G.S. Young, Research Assistant, Ph.D. candidate, Department of Electrical Engineering.

A. Rangarajan, Research Assistant, Ph.D. candidate, Department of Electrical Engineering.

S. Min, Research Assistant, Ph.D. candidate, Department of Electrical Engineering.

C.L. Wang, Research Assistant, Ph.D. candidate, Department of Electrical Engineering.

Dr. Herb Barad, Formerly Research Assistant, Ph.D. candidate, now at Temple University.

Dr. John Hsiao, formerly Research Assistant, Ph.D. candidate, now at Hughes Aircraft company.

Dan Antzoulatos, Research Assistant, Ph.D. candidate, Department of Electrical Engineering.

Dimitris Kalivas, Research Assistant, Ph.D. candidate, Department of Electrical Engineering.